



Jun 4th, 10:00 AM

Apollo 13 Lessons Learned

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APOLLO 13 LESSONS LEARNED



APOLLO 13 AQUARIUS

APRIL 1970

A handwritten signature in cursive script, reading "James A. Lovell".

JAMES A. LOVELL
ASTRONAUT

A handwritten signature in cursive script, reading "John L. Swigert, Jr.". The signature is stylized and somewhat difficult to read.

JOHN L. SWIGERT, JR.
ASTRONAUT

A handwritten signature in cursive script, reading "Fred W. Haise".

FRED W. HAISE
ASTRONAUT



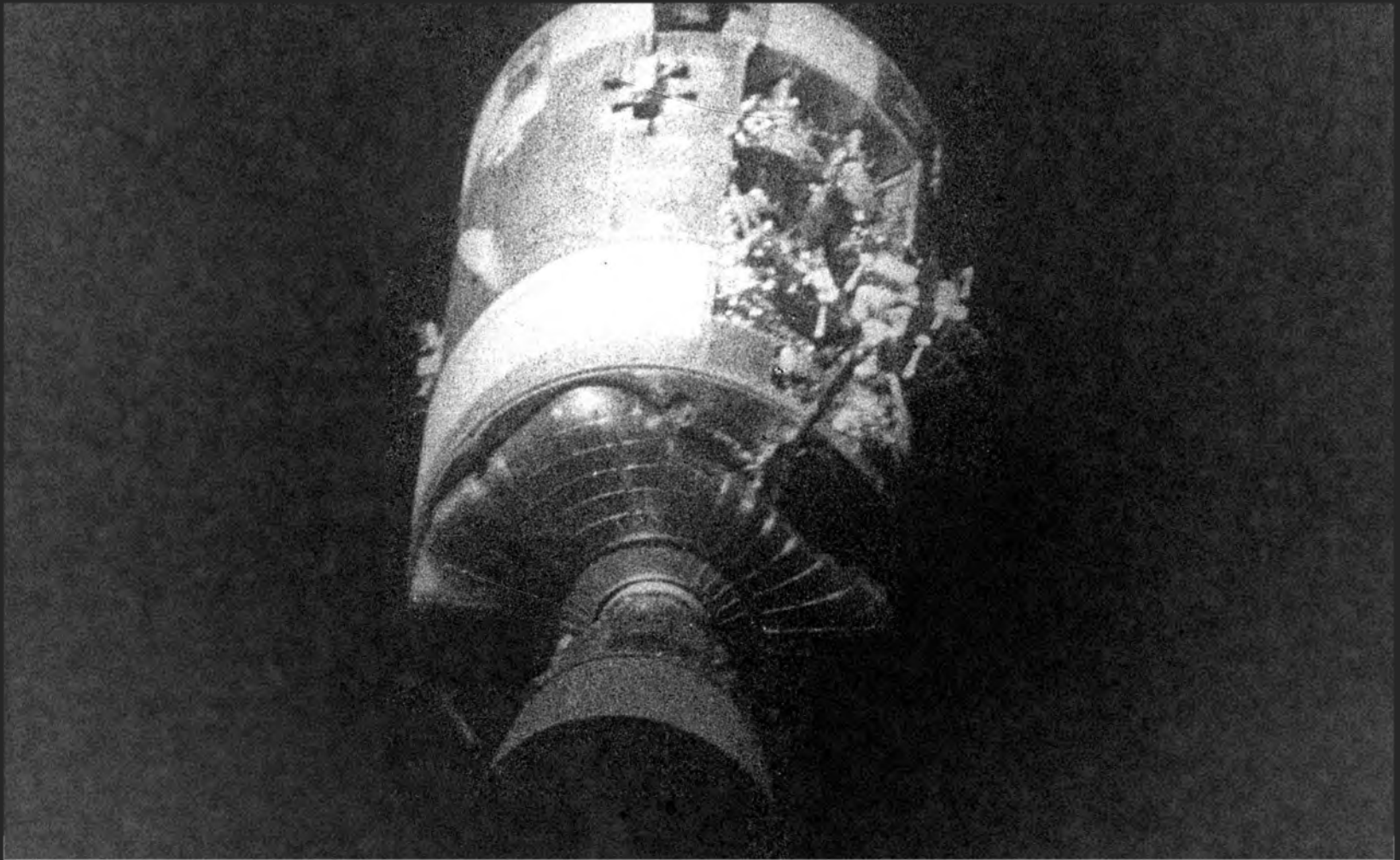


OKING









OXYGEN TANK 2 EXPLOSION IN SERVICE MODULE

ONE QUARTER OF SPACE CRAFT BLOWN OFF

<u>MET</u>	<u>TIME FROM EXPLOSION</u>	<u>ACTIVITY</u>
55 + 53	0	O ₂ TANK 2 EXPLOSION
55 + 55	2	REOPEN RCS QUAD D HELIUM ISOLATION VALVE
55 + 59	6	FUEL CELL 1 TO MAIN A AND FUEL CELL 3 TO MAIN B
56 + 03	8	BATTERY A TO MAIN BUS A
56 + 05	13	ALL RCS THRUSTERS OFF - CREW ACTION
56 + 08	15	FUEL CELL 1 OPEN CIRCUITED
56 + 14	21	MCC ALERTED OF SURVIVAL SITUATION, PREPARE FOR LM ACTIVATION
56 + 15	22	RCS QUAD C TO MAIN BUS A, PLACE B3 AND B4 TO MAIN BUS A, INITIATE FIRST POWERDOWN OF NONESSENTIAL ITEMS - 10 AMP (~300 WATTS)
56 + 25	32	AC BUS 2 TO INVERTER 1
56 + 26	33	FUEL CELL 2 PUMP TO AC BUS 1
56 + 27	34	RCS A3 TO MAIN BUS A
56 + 31	38	BODY MOUNTED ATTITUDE GYRO (BMAG) 2 AND LIGHTS - OFF
56 + 33	40	RCS QUAD B - OFF, QUAD D TO MAIN BUS A, OPEN CIRCUIT FUEL CELL 3
56 + 36	43	REMOVE BATTERY A FROM MAIN BUS A, ISOLATE O ₂ SURGE TANK, AND O ₂ TANK 1 HEATERS - ON
56 + 38	45	ISOLATE O ₂ REPRESS PACKAGE
56 + 40	47	O ₂ TANK 1 CRYO FANS - ON AND CHECK ALL CRYO CIRCUIT BREAKERS
56 + 45	52	READ OUT ALL ONBOARD D&C
56 + 46	53	BMAG 1 - OFF
57 + 06	73	FUEL CELL 3 SHUTDOWN
57 + 14	81	FUEL CELL 2 SHUTDOWN
<hr/>		<hr/>
57 + 19	86	TWO CREWMEN TO LUNAR MODULE
57 + 27	94	HIGH GAIN ANTENNA AND OVERBOARD DUMP HEATERS - OFF
57 + 39	106	CHARGE BATTERY A
57 + 49	116	O ₂ TANK FANS - ON
57 + 53	120	TERMINATE BATTERY A CHARGING
57 + 56	123	PRIMARY COOLANT LOOP RADIATORS - BYPASS, GLYCOL PUMPS - OFF
58 + 04	131	O ₂ TANK 2 FANS AND ALL RCS HEATERS - OFF
58 + 18	145	BATTERY A TIED TO MAIN BUS A
		O ₂ TANK 1 HEATERS AND FANS, IMU, COMPUTER (CMC), IMU HEATERS, BACKUP CONTROL (SCS) ELECTRONICS, "EIGHT BALL" ATTITUDE INDICATORS, AUTO JET SELECT, HAND CONTROLLERS, AND AUTO COILS - OFF
58 + 27	153	DIRECT RCS AND HAND CONTROLLER - ON
58 + 36	162	FUEL CELL 2 SHUTDOWN
58 + 40	166	BATTERY A OFF MAIN A, ISOLATE BATTERIES A, B, C, MAIN BUS TIES - OFF

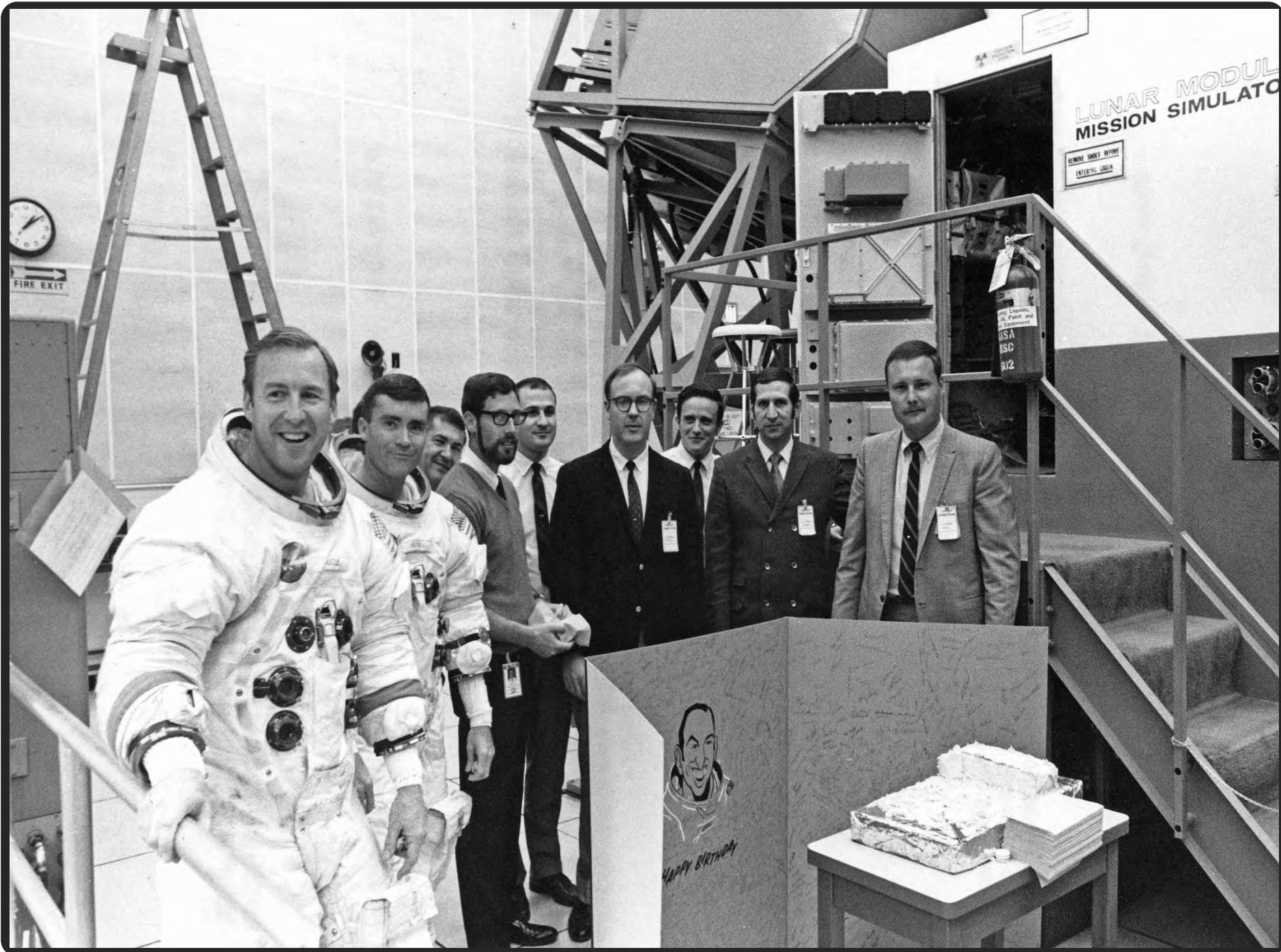
NO ATTITUDE CONTROL
FOR 8 MINUTES

CSM DEAD

DEALING WITH EMERGENCIES

- Be Knowledgeable ... know your system, procedures inside and out
- Reinforce with training, training, training

Lesson Learned: In an emergency it is too late to learn Success or failure depends on what is already imbedded in your mind!



DOCKED DPS BURN
(MANUAL)~~V76E~~ V76E

GUID CONT - AGS

MODE CONT ~~(BOTH)~~ OFF ~~(BOTH)~~

ENG STOP (2) - RESET

ABORT/ABORT STAGE - RESET

-6:00 ~~MODE CONT~~ ~~PCNS~~ ~~ATT HOLD~~~~V41 N20E, E, E, E~~~~V41 N20E, E, E, E~~

At burn attitude:

DEDA 400+5

~~V40 N20E~~ ~~V40 N20E~~~~V25 N07E, 77E, 10000E, 1E~~~~V01 N01E, 77E (Verify A = 1,3,5,7)~~~~V37E 51E, PRO, V37EQ0E~~~~400 + 5~~

CAUTION

~~At burn attitude:~~~~400 + 0~~after 400+0 do not go out if
Detent with XA~~V37E 47E~~

When CMPTR ACTY Lt - ON

~~V06 N65 E~~

hrs	min	sec
---	---	---
---	---	---
---	---	---

Load N65 Into N38:

V25 N38E

hrs)	E
min)	E
(.01 sec)	E

404 + 0

405 + 0

406 + 0

470R

DOCKED DPS BURN
(PGNS)

DOCKED APS BURN

30-MIN ACTIVATION

Basic Date 1/6/70
Changed

LM-7

+	0.1	
---	-----	--

P30 UPDATE (LM)

NOCKEN ABC DIDD

Basic Data Changed -

REMARKS:

$$\begin{array}{r} 79 \\ 57 + 11 \\ \hline 22 \\ 63 \\ \hline 85 \end{array}$$

M-7

~~DPS GDA P 5.86~~
~~P 6.75~~

WATER

333 # Desc
85 # Acc
12 # PLS
430 # TOTAL
Q1. wa.

133
59

$$\begin{array}{r} 22 \\ 22 \\ \hline 52 \end{array} \quad \begin{array}{r} 22 \\ 30 \\ \hline 52 \end{array}$$

EPS

7600
620
1222

222

$$\begin{array}{r} 2220 \\ - 63 \\ \hline \end{array}$$

150
10

5
A2
A2
A2

$$\begin{array}{r} 30 \\ 63 \end{array}$$

10

5.1

2 + 4
9 +

PROVIDE BLANK PAPER

- No blank paper available requiring use of inside & back covers of checklists & blank "burn cards"
- Several changes to the same procedures accommodated by use of different writing device on each ball point pen, pentel pen, & mechanical lead pencil

“REAL” CAUSE OF EXPLOSION

- Loss of configuration control
- All oxygen tanks recycled to make all components compatible with KSC ground power
- Thermostats controlling heaters in tank *not changed!*

Lesson Learned: *One must pay attention to the details! Physically separate critical system elements!*





WHAT ENABLED SUCCESS

- The right people – background, education, team player, etc.
- Training ++ focused on Mission & Goals
- The right leadership from top to bottom
 - Administrator simply asked what could he do to help
 - Flight Directors & Flight CDR clearly in command – chain of command clear
- The right process & policy in place & proven

STRATEGIC CHANGE TO PROCESS MADE

- Normal procedure of working abnormal problems through the MER changed – took too much time!
- Gene Kranz formed a hand picked “brain trust” to expedite solutions & decisions
 - For each open item the “right” individual was assigned the task
 - Schedule fixed to return with solution
 - Workarounds verified to the extent possible
 - Implementation through normal Mission Control practice

